Oxygen Index Test

in accordance with
ASTM D 2863, Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)

Materials and Processes Laboratory
Materials Test Branch, Building 4623

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Release Authority	Name	Title	Organization	Date
Office of Primary Responsibility	_____	Materials Test Branch Chief	EM10	_____
	_____	Industrial Safety	QD50	_____

Revision	Date	Originator	Description	Affected Pages
Baseline	x/xx/06	Eddie Davis		

This document baselines the Organizational Work Instruction (OWI) for performing oxygen index tests in Building 4623. Any deviation to this procedure shall be approved by the test engineer via an approved test plan. Any changes to the test equipment shall be noted on the tester maintenance log and approved by the test engineer. It is the responsibility of the test engineer to obtain NASA Contracting Officer's Technical Representative (COTR) approval where necessary for changes to the test equipment.

Any change to this OWI shall be submitted to and approved by the Materials Test Branch Chief, EM10. Revisions may be also be submitted to the concurring organizations listed below for review and concurrence by memo. The original OWI and all changes shall be maintained by EM10. Any change to materials used requires a change to mechanical drawings, in addition to EM10 Chemistry Team Lead approval. All documentation shall be approved by the appropriate persons mentioned above and incorporated into the OWI before operation of the reconfigured test equipment resumes.

Concurring organizations:
Building 4623 Test Operations Contractor
EM10 Chemistry Team Lead
Environmental Health, AD60M

Contents

To be revised

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1.0 Scope

1.1 Scope

The scope of this Operational Work Instruction (OWI) is ASTM D2863, *Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)*, as performed in Marshall Space Flight Center's (MSFC's) Building 4623. This test method covers a fire-test-response procedure and describes a procedure for measuring the minimum concentration of oxygen that just supports flaming combustion in a flowing mixture of oxygen and nitrogen.

1.2 Purpose

Methods are provided for testing materials that are structurally self-supporting in the form of vertical bars or sheet up to 10.5 mm thick. These methods are suitable for solid, laminated, or cellular materials characterized by an apparent density greater than 15 kg/m^3. The methods may also be applicable to some cellular materials having an apparent density of less than 15 kg/m^3. A method is provided for testing flexible sheet or film material while supported vertically.

1.3 Applicability

This instruction applies to the Chemistry Team, Materials Test Branch, of the Materials and Processes Laboratory. The test method shall be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and shall not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. Results of this test may be used, however, as elements of a fire-risk assessment that takes into account all of the factors pertinent to an assessment of the fire hazard of a particular end use.

2.0 Applicable Documents

ASTM D 2863. *Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)*.

EM10-OWI-042. *Test Sample Preparation for Testing in Building 4623.*

EM10-OWI-050. *Building 4623 Guidelines for Test Operations*.

EM10-OWI-051. *Receipt, Handling, Prioritizing, and Data Requirements of Samples Submitted for Testing in Building 4623 of the Material and Processes Laboratory*.

EM10-OWI-058. *Chemical Hygiene for Building 4623.*

ISO 4589-2. *Plastics -- Determination of Flammability by Oxygen Index-Part 2, Ambient Temperatures.*

MPD 1840.3. *MSFC Respiratory Protection Program*.

MPR 1040.3. *MSFC Emergency Plan*.

MPR 1840.2. *MSFC Hazard Communication Program*.

MPR 8715.1. *MSFC Safety, Health, and Environmental (SHE) Program*.

MSFC-SPEC-164B. *Specification for Cleanliness of Components for Use in Oxygen, Fuel, and Pneumatic Systems.*

MWI 3410.1D. *Personnel Certification Program*.

MWI 8621.1A. *Close Call and Mishap Reporting and Investigation Program*.

Note: Personnel **shall** always **reference** the current version of an applicable document.

3.0 Definitions

3.1 Definitions

Ignition. The initiation of flaming combustion.

Limited access. A term meaning, "Only the test operator shall enter the test cell with appropriate personal protective equipment."

NASA. Marshall Space Flight Center EM10 responsible personnel.

No access. A term meaning, "No one shall enter the test cell."

Oxygen index. The minimum concentration of oxygen determined by the method described in this OWI, expressed as volume percent, in a mixture of oxygen and nitrogen that just supports flaming combustion of a material initially at 23 (±2) °C under the conditions of this test method

Tag out. Placement of a tag-out device on an energy-isolating device to indicate that the energy-isolating device and equipment being controlled shall not be operated until the tag-out device is removed by the person who placed it there.

Test area. The portion of Building 4623 and fenced area south of the north wall of Room 126d.

Test cell. Room 126d of Building 4623, which contains the oxygen index testing equipment.

Test engineer. The person responsible for correctly following the approved test plan for a specific test -- from sample receipt to test data evaluation.

Test operator. The person responsible for conducting a test under the guidance of the test engineer.

3.2 Acronyms

MSDS	Material Safety Data Sheet
MSFC	Marshall Space Flight Center
OI	Oxygen Index
OWI	Organizational Work Instruction
PMMA	Poly(methyl methacrylate)
RH	Relative Humidity

3.3 Symbols

C_o Oxygen concentration in percent volume

C_F Final value of oxygen concentration in percent volume

C_i Each of the oxygen concentration percentages used during measurement of the last six responses in the N_T series

O Neither the period nor extent of burning exceeds the relevant limit specified in Table 2

X Either the period or extent of burning exceeds the relevant limit specified in Table 2

N_L Series of "X" or "O" results

N_T Series of "X" or "O" results plus five ($N_T=N_L + 5$)

σ^* Standard deviation of the oxygen concentration

d Interval between oxygen concentrations levels in percent volume

k Factor to be determined from Table 3

n Number of measurements of oxygen concentration

4.0 Instructions

All operations of this equipment **shall be conducted** using the applicable documents referenced above (section 2). All data and test results **shall be recorded** on the Oxygen Index Test Data Sheet (section 7, Figure 7-1). A summary of pertinent test information and test results **shall be compiled** in an NASA memo, **signed** by the test organization management, and **mailed** to the test requester.

4.1 Sample Preparation

The *sample preparation technician* **shall prepare** oxygen index samples according to EM10-OWI-042, *Test Sample Preparation for Testing in Building 4623.* When non-standard samples are to be tested, the *sample preparation technician* **shall follow** the directions written in the test plan for that test request. *If this information is not provided with the test plan*, the *sample preparation technician* **shall seek clarification** from the test engineer.

Before testing begins, the *test operator* **shall review** the information supplied on the test data sheet (prepared by the sample preparation technician) to make certain the information is complete and appears sound. *If a problem is identified*, the *test operator* **shall notify** the test engineer. The *test operator* shall also*:*

- **Verify** that the test request number and material designation are identical on all paperwork.
- **Confirm** that the prepared samples agree with the test request.
- **Verify** that the sample preparation technician has noted if the sample has been cleaned or if the sample does not require cleaning.
- **Note** any flaws or imperfections in the sample, and **record** these on the test data sheet.
- **Review** the test plan signed by NASA and the original test request before proceeding. *If the test plan and the test request do not agree*, **request** clarification from the test engineer, who shall query NASA.

4.2 Pre-Test Photography

The *sample preparation technician* **shall take** a pre-test photograph of at least one of the samples and **place** three copies of the photograph in the test folder. *If the pre-test photograph has not been taken*, the *test operator* **shall take** the photograph and **place** three copies of the photograph in the test folder before conducting the test. The entire sample **shall be visible** in the photo. Steps for sample photography are outlined in the *Photography Operating Guide*.

4.3 Equipment Checkout

At the beginning of the test day, the *test operator* **shall perform** the following steps:

4.3.1. **Observe** the oxygen monitors (Zone 12) located on the east wall of Room 113. If the oxygen level for Zone 12 (indicated by the digital readout) is not between 19.5% and 23.5% oxygen, **do not enter** the test cell. **Notify** the lead engineer.

4.3.2. **Verify** that the test cell floor is visibly clean. *If conditions warrant*, **scrub** the floor of the cell with a detergent solution, and **rinse** with water.

4.3.3. **Verify** that the fume hood over the tester is operating correctly.

4.3.4. **Verify** that gas lines are securely attached to the rear panel ports.

4.3.5. **Verify** that the control unit selection switch (located on the control unit rear panel) is set to 110 V.

4.3.6. **Press** the **POWER** button to turn on the unit. **Verify** that the **POWER** button lights up and that the temperature and oxygen concentration displays are functioning.

4.4 System Setup

The *test operator* **shall perform** the following steps:

4.4.1. **Inspect** the contents of the current test folder to verify that the following information is provided:

- Test request
- Signed test plan
- Test data sheets
- Sample preparation sheet
- Test material's MSDS or the Exclusion Statement for the material/component being tested
- Pre-test photographs (**See** section 4.2.)
- Oxygen Index Pre-Test Checklist (Figure 7-1).

WARNING: Read the test material's MSDS to verify familiarity with all safety precautions associated with the material. Verify that the test engineer is aware of all highly hazardous, reactive, or toxic components of the test material. The *test engineer* **shall direct** the test operator in proper safety procedures concerning these test materials.

4.4.2. **Turn on** warning lights to indicate that hazardous testing is in progress. This places the test area in a *limited-access* condition.

4.4.3. **Don** safety glasses.

4.4.4. **Allow** 1 hour for the oxygen cell to warm up and stabilize before calibrating and testing. *If the unit is used without performing this warmup,* the **% Oxygen** reading may drift and exhibit instability.

4.4.5. **Turn on** the extraction system. **Set** the nitrogen and oxygen gas regulators to 2.0 bar (29 psig) if the instrument has a standard flowmeter (1-12 *l*/min air) or 2.75 bar (39.9 psig) if a 2-25 *l*/min air flowmeter is fitted. **Do NOT allow** the line pressure to exceed 3 bar (43.5 psig), as damage to the oxygen analyzer may result.

4.4.6. **Verify** that the Flow Control needle valve located on the rear of the apparatus is fully open (fully counterclockwise), that the nitrogen and oxygen needle valves located on the front of the apparatus are approximately half open, and that the nitrogen and oxygen **ON/OFF** valves on the front of the control unit are in the **OFF** position. (**Refer** to illustrations in section 9.)

4.4.7. **Check** all internal connections for leaks, and **seal**, *if necessary.*

4.4.8. **Place** the lower debris screen (the smaller of the screens) over the test sample holder support, and **allow** it to fall into position. **Place** the upper debris screen over the test sample holder support so that it rests on the chimney support. **Place** the cover plate over the chimney support, with the magnetic strips toward the top cover of the unit. **Position** a chimney in place.

4.4.9. **Slowly turn** the nitrogen **ON/OFF** ball valve to the **ON** position, so that only nitrogen is flowing through the system. **Turn** the nitrogen needle valve so it is fully open; **do not backseat** the valve. **Turn** the Flostat needle valve on the back of the instrument (labeled Flow Control) clockwise to close it until the flowmeter indicates a flow rate equivalent to 40 ($\pm$2) mm/sec through the chimney.

For a glass chimney of internal diameter 75 mm, 40 mm/sec linear flow is indicated by 10.6 *l*/min; for an internal diameter of 100 mm, this linear flow is indicated by 18.8 *l*/min.

Note: Take the flowmeter reading at the top of the float.

4.4.10. For a glass chimney internal diameter other than 75 mm or 100 mm, **calculate** the specified flow rate using equation (1):

$$V=1.5xl0^{-5} \cdot \pi \cdot \mu \cdot D^2 \qquad (1)$$

where:
V = the specified volume flow rate (*l*/min)
μ = the equivalent linear flow rate [40 (±10) mrn/sec]
D = the internal diameter of the glass chimney (mm)

Note: This procedure verifies that the Flostat is not in saturation.

4.4.11. **Allow** the oxygen analyzer to stabilize at or near zero (about 1 minute). While observing the **% Oxygen** meter, **use** a flat blade screwdriver to adjust the **Zero** adjust on the oxygen analyzer until a reading of 0.0% is achieved.

4.4.12. **Turn** the nitrogen valve to the **OFF** position, and **slowly turn** the oxygen valve to the **ON** position. **Turn** the oxygen needle valve so that it is fully open.

4.4.13. Assuming the same line pressure for nitrogen and oxygen, the flow rate indicated shall be the same as that indicated in step 4.4.6 or step 4.4.7. *If it is not,* **readjust** the **oxygen pressure regulator** until the required flow rate is obtained. This verifies that the two gases are at the same pressure.

4.4.14. Using the **Span** adjust on the front panel, **match** the **% Oxygen** display reading with the supplied oxygen cocentration. *If using an oxygen supply bottle,* the reading shall match one of the following purity grades: 99.5% for commercial grade or 99.9(5)% for high purity oxygen. *If using the Building 4623 facility oxygen supply,* set the **% Oxygen** display to read 99.9(5)%.

4.4.15. **Turn** the oxygen valve to the **OFF** position. **Turn** the nitrogen valve **slowly** to the **ON** position, and then **turn** the oxygen valve **slowly** to the **ON** position. **Turn** the oxygen needle valve clockwise to close it until a desired oxygen concentration at the flow rate used in steps 4.4.6 and 4.4.7 is displayed.

Note: The Flostat is designed to maintain a constant flow rate through the flowmeter, regardless of the oxygen and nitrogen needle valve positions, providing that at least one of the needle valves remains **fully** open.

4.4.16. **Verify** that the neck valve on the igniter (located immediately downstream of the igniter handle) is closed. **Turn on** the propane bottle, **set** the regulator to 1.0 psig, **open** the neck valve only a crack, and **ignite** the gas at the end of the tube. **Place** the tube vertically in the chimney, and **adjust** the neck valve to obtain a flame that projects 16 (±4) mm (0.63 in.) vertically downward.

4.4.17. **Remove** the igniter from the chimney, **shut off** the propane supply from the bottle, and **allow** the gas in the line to flare off before closing the neck valve on the igniter.

4.4.18. Follow these steps to set up the video equipment:

4.4.18.1. **Turn on** video equipment (monitor, VCR, camera, *etc.*).

4.4.18.2. **Ensure** that the field of view of the camera includes the test specimen and the control panel temperature and oxygen concentration readouts. The camera's focus **shall be** on the temperature and oxygen concentration readouts.

4.4.18.3. **Obtain** the latest available video cassette numerically identified by the year, *e.g.,* 06-, 07-, followed by the tape number, *e.g.,* -01, -04. *If the time remaining on the cassette is less than 25 minutes,* **start** a new tape, and **identify** the tape with the next available tape number in the video tape log book in the video file cabinet. The video tape in use is left in the recorder.

4.4.18.4. **Record** the video cassette number and the test start counter/frame number on the test data sheet.

4.4.18.5. **Prepare** a test information sign for the video tape using the character generator. The sign **shall contain** the following information:

- Request number
- Sample set number (if applicable)
- Test type (Oxygen Index or Elevated Temperature Oxygen Index)
- Sample number
- Test atmosphere
- Material designation
- Date
- Test Conductor initials.

4.5 Sample Loading

The *test operator* **shall perform** the following steps:

4.5.1. **Inspect** the surfaces of the test samples to verify that they are clean and free from flaws that could affect burning behavior, *i.e.,* peripheral molding flash or burrs.

4.5.2. To monitor the distance over which a test sample burns, the sample may be marked with transverse lines at one or more levels, depending on sample form and ignition procedure. *If the sample preparation technician has already marked the sample,* **proceed** to step 4.5.2.4 for Type V samples or to step 4.5.3 to Types I - IV.

4.5.2.1. **Mark** self-supporting samples on at least two adjacent faces. *If using wet ink,* **verify** that the marks are dry before the test sample is ignited.

4.5.2.2. **Mark** test samples of Types I, II, III, or IV that will be tested in accordance with Procedure A (top surface ignition) 50 mm from the end to be ignited.

4.5.2.3. **Mark** specimens of Types I, II, III, or IV scheduled for testing in accordance with Procedure B at 10 mm and at 60 mm from the end to be ignited.

4.5.2.4. Reference marks for Type V test samples are on the supporting frame; however, for convenience, these may be marked at 20 mm and at 100 mm from the end to be ignited when testing heat-stable materials. **Verify** that, when mounting a test sample in the holder, the marks on the frame correspond with those on the sample.

4.5.3. *If necessary,* **keep** the test samples in an enclosure at 23 (±2) °C and 50 (±5) % relative humidity (RH); **take** the test samples out of the enclosure just before testing.

4.5.4. **Mount** a test sample in the test sample holder. **Place** the sample holder/ test sample assembly onto the supporting stem. **Verify** that the test sample is vertically and centrally positioned in the sample holder. **Install** a clean ambient temperature chimney. **Verify** that the top of the test sample is at least 100 mm below the open top of the chimney and that the lowest exposed part of the test sample is at least 100 mm above the top of the lower debris screen.

4.6 Detailed Test Procedures

If the actual oxygen index of a material is needed or in case of a dispute, **use** Procedure A, as described in section 4.6.1. Otherwise, **use** Procedure B, described in section 4.6.2.

4.6.1. Procedure A

4.6.1.1. **Verify** that the ambient temperature for the test apparatus is 23 (±2) °C.

4.6.1.2. **Verify** that both the oxygen and nitrogen valves are in the **OFF** position.

4.6.1.3. **Select** an initial concentration of oxygen to be used.Whenever possible, **base** the initial concentration on experience of results for similar materials. Alternatively, **try to ignite** a test sample in the air, and **note** the burning behavior. *If the test sample burns rapidly,* **select** an initial concentration of about 18% oxygen; *if the test sample burns gently or unsteadily,* **select** an initial oxygen concentration of about 21%; *if the test sample does not continue to*

burn in air, **select** an initial concentration of a least 25%, depending upon the difficulty of ignition or the period of burning before extinguishing in air.

4.6.1.4. **Turn** the nitrogen valve **slowly** to the **ON** position; turn the oxygen valve to the **ON** position.

Note: Turning the valves slowly to the **ON** position avoids an undesirable initial flow surge, a result of the back pressure in the system. When turning on the valves, always **turn** the nitrogen valve on fully before turning the oxygen valve.

4.6.1.5. **Use** the oxygen gas needle valve to obtain the selected oxygen concentration at the flow rate used in steps 4.4.9 and 4.4.10.

Note: For oxygen concentrations in excess of approximately 50%, the oxygen needle valve shall be fully open, and the nitrogen valve shall be used to obtain the calculated oxygen concentration. Always **verify** that one of the needle valves is fully open, using the other to adjust the concentration.

4.6.1.6. **Let** the gas flow purge the chimney for at least 30 sec before ignition of each test sample. **Maintain** the flow without change during ignition and combustion of each test sample.

4.6.1.7. With the character generator in the **RECORD TITLE** mode, **record** the test information sign on video for at least 10 seconds. After 10 seconds, **switch** the character generator to the **STOP WATCH** mode, and **ensure** that the stop watch is reset to 00:00:00.

4.6.1.8. **Verify** that the temperature at the lower end of the chimney is 23 (±2) °C, and **record** the oxygen concentration used as the volume percent in the appropriate Oxygen Index Data Sheet (Figure 7-1) cell.

4.6.1.9. **Select** one of the following two ignition methods, depending on the test sample form:

4.6.1.8.1. For test sample Types I, II, III, IV, and VI, **select** Method A, Top Surface Ignition. **Proceed** to step 4.6.1.9.

4.6.1.8.2. For test sample Type V, **select** Method B, Propagating Ignition. **Proceed** to step 4.6.1.10.

Note: For tests on materials that exhibit steady burning and spread of combustion in oxygen concentrations at, or close to, their oxygen index value, or for self-supporting test samples ≤3 mm (0-12 in.) thick, Method B may give more consistent results than Method A. Method B may then be used for test samples of Types I, II, III, or IV.

4.6.1.9. **Perform** Top Surface Ignition (Method A).

4.6.1.9.1. **Use** the igniter to initiate burning only on the top surface of the upper end of the test sample. **Apply** the lowest visible part of the flame to the top of the test sample. **Use** a sweeping motion, *if necessary,* to cover the whole surface, but **take care** not to maintain the flame against the vertical faces or edges of the test sample.

4.6.1.9.2. **Apply** the flame for up to 30 sec; **remove** it briefly every 5 sec to observe whether the entire top surface of the test sample is burning.

Note: The test sample is considered to be ignited as soon as removal of the igniter (after a contact period increment of 5 sec) reveals burning supported by the whole of the top end of the sample.

4.6.1.9.3. **Begin** measurement of the period and distance of burning when the test sample is ignited by pushing the **START/STOP** button on the character generator.

4.6.1.10. **Perform** Propagation Ignition (Method B)

4.6.1.10.1. **Use** the igniter to produce burning across the top and partially down the vertical faces of the test sample.

4.6.1.10.2. **Lower** and **move** the igniter sufficiently to apply the visible flame to the end face of the test sample and to a depth of approximately 6 mm to its vertical faces. **Apply** the igniter for up to 30 sec, interrupting application to inspect the test sample every 5 sec, until:

- its vertical faces are burning steadily or
- the visibly burning portion first reaches the level of the upper reference mark on the support frame or, if used for test samples of Type I, II, III, IV or VI , the reference mark on the sample.

Note: The test sample is considered to be ignited as soon as any part of the visibly burning portion reaches the level of the upper reference mark.

4.6.1.10.3. **Begin** measuring the period and extent of burning when the test sample is ignited by pushing the **START/STOP** button on the character generator.

4.6.1.11. **Assess** and **record** the burning behavior of the test sample as described in section 4.8 and in accordance with the Oxygen Index Data Sheet (section 7, Figure 7-1). *If burning ceases but spontaneous reignition occurs within 1 sec,* **continue** the observation and measurements.

4.6.1.12. **Return** both gas valves to the **OFF** position.

4.6.1.13. **Remove** the test sample, and as necessary, **clean** any surfaces within the chimney or on the igniter that have become contaminated with soot, *etc.*

4.6.1.14. **Allow** the chimney to regain a temperature of 23 (±2) °C, or **replace** it with another so conditioned.

4.6.1.15. **Determine** the oxygen index of the test material by performing the following steps:

4.6.1.15.1. **Mount** a new test sample, and **choose** a new oxygen concentration while adhering to the following: **decrease** the oxygen concentration *if the burning behavior of the preceding test sample yielded an "X,"* or **increase** the oxygen concentration *if the burning behavior of the preceding test sample yielded an "O."* The determining criteria for the size of the decreasing or increasing oxygen concentration are found in step 4.6.1.15.2 or step 4.6.1.15.4.

4.6.1.15.2. Determining the Preliminary oxygen concentration involves burning a number of test samples while using a series of oxygen concentration changes of any convenient step size. These changes **shall be made** until two oxygen concentrations are found to differ by ≤1.0% and of which one gave an "O" response and the other an "X" response. The oxygen concentration yielding the "O" response is the Preliminary oxygen concentration.

Note: The pair of oxygen concentrations resulting in the Preliminary oxygen concentration need not be the result of two consecutive test samples.

4.6.1.15.3. **Test** another sample at the Preliminary oxygen concentration, and **record** its response. A response different than that of the original test is acceptable. This test is the first in the $N_L - N_T$ series of tests.

4.6.1.15.4. **Test** a new sample with an oxygen concentration change step size of d = 0.2% (**refer** to section 7.1.1) and with the step direction in accordance with step 4.6.1.15.1. **Record** the oxygen concentration and the test sample response. **Continue** to repeat this step until a response different than that observed in first test of this step occurs. The group of same response tests conducted in this step before this opposite response constitutes the N_L series.

4.6.1.15.5. **Test** four more test samples with an oxygen concentration change step size of d = 0.2% and with the step direction in accordance with step 4.6.1.15.1. **Record** the oxygen concentration and the test sample response for each test. The last five tests and the tests in the N_L series constitute

the N_T series; therefore, $N_T - N_L = 5$. These results are recorded on the Oxygen Index Data Sheet (Figure 7-1).

4.6.1.15.6. **Calculate** the estimated standard deviation of the oxygen concentration (σ^*) measurements from the last six responses in the N_T series (including C_F). (**Refer** to section 7.1.3.) *If the condition* $2\sigma^*/3 < d < 3\sigma^*/2$ *is satisfied,* **calculate** the oxygen index (OI). (**Refer** to section 7.1.1.).

Note: *If* $d<2\sigma^*/3$, **repeat** steps 4.6.1.15.3 through 4.6.1.15.5 using **increased** values for *d* until the condition is satisfied.

Note: *If* $d>3\sigma^*/2$, **repeat** steps 4.6.1.22.3 through 4.6.1.22.5 using **decreased** values for *d*, until the condition is satisfied, with one exception: that *d* shall not be reduced below 0.2% unless so directed by the relevant material specification.

4.6.1.16. When testing is complete and the unit has been shutdown in accordance with section 4.7, **clean** the unit, chimney, debris screens, and test sample holders using non-abrasive cleaners.

4.6.2. Procedure B (Procedure C in ISO 4589-2)

Procedure B is a comparison with a specified minimum value for OI (short procedure). *If the actual oxygen index of a material is needed or in case of a dispute,* **use** Procedure A, described in section 4.6.1.

4.6.2.1. **Follow the** instructions for setting up the apparatus and the test sample as described in steps 4.6.1 through 4.6.1.8, with the following exception: **use** the specified minimum concentration of oxygen in place of the initial oxygen concentration establishment method described in step 4.6.1.3.

4.6.2.2. **Ignite** the test sample in accordance with steps 4.6.1.9 or 4.6.1.10.

4.6.2.3. **Use** up to 3 test samples to assess the burning behavior of each sample as described in section 4.8. *If, for at least two of the three samples tested, the flame is extinguished before attaining the relevant criteria from Table 7-1, i.e., if an "O" response is recorded,* **record** that the oxygen index of the materials is not less than the specified value. Otherwise, **record** that the oxygen index of the material is less than the specified value, or **determine** the oxygen index in accordance with section 4.6, as appropriate.

4.6.2.4. When testing is complete and the unit has been shutdown in accordance with section 4.7, **clean** the unit, chimney, debris screens and test sample holders using non-abrasive cleaners.

4.7 Shutdown Procedure

4.7.1. **Secure** the nitrogen and oxygen supplies, and **allow** the Oxygen Index gas circuits to equalize with ambient atmospheric pressure. After the gas circuits have equalized, **turn** the nitrogen and oxygen **ON/OFF** ball valves to the **OFF** position.

4.7.2. **Verify t**hat the propane bottle is turned off, and **flare** off the excess propane in the line by opening the neck valve and igniting the gas.

4.7.3. **Clean** the units, chimney, debris tray, and test sample holders using non-abrasive cleaners.

4.7.4. **Press** the power button to turn off the control unit.

4.8 Data Recording and Reduction; Post-Test Photography

4.8.1. Data Recording. **Refer** to Table 4-1.

Table 4-1. Criteria for OI Measurements

Test Sample Type	Ignition Procedure	Alternative Criteria	
		Period of Burning after Ignition (sec)	Extent of Burning*
I, II, III, IV, and VI	A (top surface ignition)	180	50 mm below top of specimen
	B (propagating ignition)	180	50 mm below upper reference mark
V	Propagating ignition	180	80 mm below upper reference mark on frame

*Extent of burning is exceeded when any part of the visibly burning portion of a test sample, including burning drips descending the vertical faces, passes the level indicated in the column.

4.8.1.1. *If neither the period nor extent of burning exceeds the relevant limit specified in Table 7-1 for the applicable test sample,* **note** the duration and extent of burning, and **record** as an "O" response.

4.8.1.2. *If either the period or extent of burning exceeds the relevant limit specified in Table 7-1,* **note** the burning behavior, **extinguish** the flame, and **record** as an "X" response.

4.8.1.3. **Note** the burning characteristics of the material,*e.g.,* dripping, charring, erratic burning, glowing combustion, or after-glow.

4.8.1.4. **Complete** the test report data sheet (Figure 7-2). **Place** these sheets and the completed Pre-Test Checklist (Figure 7-1) in the test folder.

4.8.2. **Photograph** reacted samples, charred or melted test equipment, or any anomalies. **Document** these in writing on the test report data sheet. **Do not photograph** post-test samples that did not react. **Take** photographs as close to the samples as

possible. More than one sample or reaction per photograph is acceptable, if the details of reactions are visible. **Refer** to the *Photography Operating Guide* for procedures for taking photographs. **Place** three copies of each post-test photograph in the test folder before returning the folder to the engineer. Photographs shall be retained indefinitely.

Note: *If there are several reactions and samples are hard to handle,* representative photos may be taken and labeled as such. The test engineer, in consultation with NASA, shall decide whether to make representative photos on a case-by-case basis.

4.8.3. **Package** post-test samples in their original packaging. **Return** the samples with the test folder to the test engineer for evaluation. The *test engineer* **shall return** samples to the *sample preparation technician* who **shall store** them for future reference.

4.8.4. **Insert** the following information in the test report:

- A reference to this test method
- Date of testing
- A statement that test results relate only to the behavior of the test samples under the condition of this test method and that these results shall not be used to infer the fire hazards of the material in other forms or under other fire conditions
- Identification of the material tested, including (where relevant) the type of material, density, previous history, test sample orientation with respect to any anisotropy in the material or sample, and the date of manufacture with lot number
- The oxygen index as determined in section 7.1.1
- The test sample type or dimensions
- The gas measurement and control device accuracy
- The ignition procedure used [Method A (step 4.6.1.16) or Method B (step 4.6.1.17)]
- When Procedure B (Procedure C in ISO 4589-2) is used, the relevant specified minimum oxygen index of the material and if the material tested had a lower or higher oxygen index than the specified minimum
- If applicable, the estimated standard deviation of the oxygen concentration increment used, if other than 0.2 percent
- A description of any relevant characteristics or behavior, such as charring, dripping, severe shrinkage, erratic burning, after-glow
- Any variations from the requirements of this test method.

5.0 Notes

Custodians for EM10-OWI-059	
Master List and Document Control	EM10 Management Support Assistant
Alternate Document Control	EM10 Group ISO Representative
Memoranda	Materials Test Branch ISO Representative

6.0 Safety Precautions and Warning Notes

6.1 Hazards

Warning
Death, severe personal injury, or loss of major equipment may result if maintenance or operating procedures, techniques, restrictions, etc., are not followed exactly.

Safety shall have precedence over all activities. Because of the nature of testing with flammable materials, the testing system involves several hazards to the operator and facility. These include:

- Potential touch temperature risks from hot surfaces
- Burning materials in air or oxygen-enriched environments
- Pressurized nitrogen and oxygen supply systems
- Electrical load and other ignition sources applied in air, oxygen-enriched environments, and combustible by-products
- Flammable and dangerous liquid solvents
- Electrical valves, power supplies, switches, and other components
- Oxygen deficiency.

6.2 Safety Precautions

Personnel **shall:**

6.2.1. **Plan** test setup, testing, and shutdown so that at least one test operator is in the test area and one other person is in Building 4623 during normal business hours. After normal business hours and on weekends, a test engineer shall be in Building 4623 during all test activities. **No more than five people** shall be in the test area at any given time. Operation of tests shall comply with EM10-OWI-050, *Building 4623 Guidelines for Test Operations.*

6.2.2. **Refer to the MSDS** for information on personal protective equipment required required for handling sample materials, solvents, gaseous nitrogen, and gaseous oxygen. **Wear**:

- Safety shoes when there is a danger of foot injuries from falling or rolling objects, objects piercing the sole of the shoe, or when feet may be exposed to an electrical hazard
- Clean laboratory coat when working with enriched oxygen or other oxidizers, combustion by-products, compressed gases, or flammable solvents
- Safety glasses at all times while in the test cell
- Chemical goggles and gloves while cleaning test equipment and while working with solvents.
- A respirator when working with solvents in closed or poorly ventilated spaces. **Note** that the appropriate respirator shall be worn as indicated on the solvent's MSDS. Cartridge respirators are only good for the constituents listed on the filtration cartridge and for dust particle filtration. Supplied air respirators shall be mandatory for exposure to certain chemicals. Personnel shall be qualified to use the respirator, and the respirator shall be supplied by MSFC.

6.2.3. **Smoking is not permitted** in Building 4623. The test area is generally an oxygen-enriched environment. Open flame or other high-temperature sources are not permissible in the testing area while enriched-oxygen conditions exist. **Do not smoke or expose clothing** to an open flame for 30 minutes after handling liquid or gaseous oxygen.

6.2.4. **Activate** the building warning system for the duration of all testing, including pre- and post-test procedures. **Evacuate** the test area immediately when the oxygen alarm sounds and lights flash.

6.2.5. *In case of an uncontrollable LOX fire*, **do not try to extinguish the fire**. **Evacuate** the area immediately. **Call 911** to notify the fire department.

6.2.6. **Do not store** anything in the test cell area other than parts or components of the testing apparatus that are designated as spare parts and the tools necessary for routine equipment maintenance. **Remove** all other materials from the test area. **Place** any spare parts that will be exposed to an enriched-oxygen environment in the secured inventory area.

6.2.7. **Verify** that the ventilation system fan is on continuously during testing, including pre-test and post-test activities, to bring in fresh air and remove fumes and other combustion by-products from the test cell.

6.2.8. **Verify** all electrical components, wiring, etc., are in good condition and properly connected and grounded. **Do not operate** electrical devices when floors in the test cell are wet. **Use caution** when operating any electrical equipment.

6.2.9. **Clean** all equipment that will contact LOX as described in section 9.4, Required Tester Maintenance, and section 4.3, Equipment Checkout, before the equipment is exposed to LOX.

6.2.10 When making connections for compressed gases, **refer** to *Working Safely with Compressed Gases and Cryogens* and *NSTC 313-Cryogenics Safety.* (**See** the test engineer for these resources.) **Comply** with the suggestions inside these presentations.

6.2.11. **Check** the building warning lights daily for proper operation.

6.3 Special Hazards Associated with Compressed Gases and Liquids

6.3.1. All operations involving compressed gases and liquids shall be conducted with at least 2 people, in visual contact, in the facility.

6.3.2. All operating personnel shall be instructed on the nature of hazards associated with compressed gases and liquids.

6.3.3. Before removal of any component of the system for servicing, the *operator* **shall secure and inspect** the system to verify that no unsafe condition exists.

6.3.4. Personnel shall perform continuous monitoring, *e.g.,* check operating pressures, look for leaks, listen for unusual noises, during all operations. Personnel shall verify that oxygen leak levels are at or near zero throughout operations.

6.4 Emergency Shutdown Procedure

The tester does not have to be shut down to be considered safe in an emergency situation.

6.5 Accident Reporting

6.5.1. From a safe location, the *test operator* **shall call 911 immediately** and **notify** the EM10 Materials Test Branch Chief.

6.5.2. From a safe location, the *EM10 Materials Test Branch Chief* **shall immediately report** the accident to the NASA Safety Monitor and the appropriate supervisor(s).

6.6 Emergency Response Plan

Emergency procedures and plans for Building 4623 are incorporated into this OWI and are stated in MPR 1040.3, *MSFC Emergency Plan.* Plans shall be modified if operations change in a significant manner.

6.7 Mishap Reporting

Personnel **shall report** all mishaps occurring in Building 4623 to the test engineer, who shall report the mishap to the area coordinator/Safety Monitor. An initial verbal report shall be made within 8 hours, followed by a written report within 3 days. The EM10 Chemistry Team Lead shall prepare a managerial report within 7 days. Both reports shall be reviewed by the test operator's supervisor and by the NASA Safety Monitor. The detail and extent of the mishap report shall depend on the nature and extent of the damage. *If personnel injury or equipment damage does occur*, the mishap report shall be completed in accordance with MWI 8621.1A, *Close Call and Mishap Reporting and Investigation Program*.

7.0 Attachments, Data, Reports, and Forms

7.1 Calculations

7.1.1. Determination of Oxygen Index. The OI is expressed as a percentage by volume and is calculated using the following equation:

$$OI = C_F + kd \qquad (2)$$

where:

C_F = the final value of oxygen concentration, in percent volume to one decimal place, used in the series of N_T measurements performed in accordance with step 4.6.1.15.5.

k = a factor to be obtained from Table 7-1 as described in section 7.1.2 (below)

d = the interval, in percent volume to at least one decimal place, between oxygen concentration levels used and controlled in accordance with step 4.6.1.15.5.

7.1.1.1. **Calculate** the value of the OI to two decimal places for the purpose of calculating σ*.

7.1.1.2. **Express** OI values to the nearest ±0.1%, with exact intermediate results being rounded downward.

7.1.2. Determination of *k*. The value and sign of *k* are dependent on the pattern of the responses of test samples tested in accordance with steps 4.6.1.15.4 and 4.6.1.15.5. **Use** Table 7-1 to determine the value and sign of *k.*

7.1.2.1. *If the response of the test sample tested in step 4.6.1.15.4 was "O," so that the first contrary response was an "X,"* **refer** to Column 1 of Table 7-1 to select the row for which the last four response symbols correspond to those found when testing in accordance with step 4.6.1.15.5. The value and sign of *k* shall be that shown in Columns 2, 3, 4, or 5 for which the number of "Os" shown in row (a) of the table corresponds to the number of "O" responses found for the N_L series, in accordance with steps 4.6.1.15.4 and 4.6.1.15.5.

7.1.2.2. *If the responses of the test sample tested in step 4.6.1.15.4 was "X," so that the first contrary response was an "O,"* **refer** to Column 6 of Table 7-1 to select the row for which the last four response symbols correspond to those found when testing in accordance with step 4.6.1.15.5. The value of *k* shall be that shown in Columns 2, 3, 4, or 5 for which the number of "Xs" shown in row (b) of the table corresponds to the number of "X" responses found for the N_L series in accordance with steps 4.6.1.15.4 and 4.6.1.15.5, but the sign of *k* must be reversed, so that negative values shown in Table 7-1 for *k* become positive and vice versa.

Table 7-1. Determination of k

1	2	3	4	5	6
Responses for the Last 5 Measurements	Values of *k* for which the First N_L Determinations Are:				Responses for the Last 5 Measurements
	(a) 0	00	000	0000	
XOOOO	-0.55	-0.55	-.055	-0.55	OXXXX
XOOOX	-1.25	-1.25	-1.25	-1.25	OXXXO
XOOXO	0.37	0.38	0.38	0.38	OXXOX
XOOXX	-0.17	-0.14	-0.14	-0.14	OXXOO
XOXOO	0.02	0.04	0.04	0.04	OXOXX
XOXOX	-0.50	-0.46	-0.45	-0.45	OXOXO
XOXXO	1.17	1.24	1.25	1.25	OXOOX
XOXXX	0.61	0.73	0.76	0.76	OXOOO
XXOOO	-0.30	-0.27	-0.26	-0.26	OOXXX
XXOOX	-0.83	-0.76	-0.75	-0.75	OOXXO
XXOXO	0.83	0.94	0.95	0.95	OOXOX
XXOXX	0.30	0.46	0.50	0.50	OOXOO
XXXOO	0.50	0.65	0.68	0.68	OOOXX
XXXOX	-0.04	0.19	0.24	0.25	OOOXO
XXXXO	1.60	1.92	2.00	2.01	OOOOX
XXXXX	0.89	1.33	1.47	1.50	OOOOO
	Values of *k* for which the First N_L Determinations Are:				Responses for the Last 5 Measurements
	(b) X	XX	XXX	XXXX	
	are as given in the above table opposite the appropriate response in column 6 but with the sign of *k* reversed				

7.1.3. Determination of Standard Deviation of Oxygen Concentration Measurement. Calculate the estimated standard deviation (σ^*) of oxygen concentration measurements using the following equation:

$$\sigma^* = [\Sigma(C_i\text{-}OI)^2/(n\text{-}1)]^{1/2} \quad (3)$$

where:

C_i = in turn, each of the percent oxygen concentrations used during measurement of the last 6 responses in the N_T series of measurements

OI = the oxygen index value, calculated in accordance with section 7.1.1.

n = the number of measurements of oxygen concentration contributing to $\Sigma(C_i\text{-}OI)^2$.

Note: For this test method, n=6, in accordance with step 4.6.1.15.6. For n<6, the test method loses precision. For n>6, alternative statistical criteria would apply. Table 7-1 values of k for calculating OI concentration are from determinations made by Dixon's "Up-and-Down" method.

7.2 Forms

Figure 7-1 contains a representative sample of an Oxygen Index Pre-Test Checklist; Figure 7-2 contains a representative sample of an Oxygen Index Data Sheet; Figure 7-3 shows a typical calibration sheet.

Oxygen Index Pre-Test Checklist

Request No. _____

Initial

1. ____ Oxygen Index OWI reviewed?
2. ____ All safety equipment checked out and working properly?
3. ____ Test equipment checked out in accordance with OWI?
4. ____ Test material's MSDS read?
5. ____ Test plan read and changes noted and approved by engineer?
6. ____ O_2 and N_2 supplies turned on?
7. ____ Operation of video monitor and camera checked?
8. ____ Facility warning light activated?
9. ____ Oxygen monitor checked to ensure normal O_2 level?
10. ____ Pre-test photographs taken?

Remarks/Discussion of Discrepancies:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ _____

Test Operator Date

xx/06 EM10-F-CHM-100

Figure 7-1.
Typical Oxygen Index Pre-Test Checklist.

Figure 7-2. Typical Oxygen Index Data Sheet.

OXYGEN INDEX DATA SHEET

Test Number: Date:
Material: Oxygen Index (concentration, %):
Sample Type (circle one): I II III IV V Standard Deviation (σ*):
Ignition procedure (circle one): A B
Conditioning Procedure:
Oxygen Concentration Increment (*d*):
PART 1. Determination of oxygen concentration for one pair of X and O response at <1% O_2 concentration interval (in accordance with 4.6.1.15.2)

Oxygen concentration (%)									
Burning period (sec)									
Length burned (mm)									
Response (X or O)									

Oxygen concentration of the O response for the pair = _____

PART 2. Determination of oxygen index value (in accordance with 4.6.1.3)
Step size to be used for successive changes in oxygen concentration of *d* % = 0.2%
(initially to be 0.2%, unless otherwise instructed):

	N_T series measurements												
	N_L series measurements							C_F					
Oxygen concentration (%)													
Burning period (sec)													
Length burned (mm)													
Response (X or O)													
	Column (2, 3, 4 or 5):												
	k value from Table 7-1:							Row (1 to 16):					
	k value, with correct sign:												

Oxygen Index Calculation (OI = $C_F + kd$): OI =

PART 3: Verification of Step Size *d*% Oxygen Concentration
(in accordance with 4.6.1.15.6 and 7.1.3)

Last 6 Results[1]		Oxygen Concentration (%)			
		C_i	OI	C_i-OI	$(C_i\text{-OI})^2$
CF	1				
	2				
	3				
	4				
	5				
n	6				
				Total $\Sigma(C_i - OI)^2$	

[1]Column 1 contains the oxygen concentrations used for the measurements of C_F and for each of the 5 preceding measurements for n=6.

Estimation of Standard deviation (σ*): $\left[\sigma^* = \frac{\Sigma(C_i - OI)^2}{n-1}\right]$

If $2\sigma^*/3 < d < 3\sigma^*/2$, OI is valid.
Otherwise,
if $2\sigma^*/3 > d$, repeat Part 2 using a larger value for *d*.
if $3\sigma^*/2 < d$, repeat Part 2 using a smaller value for *d*.

Test Conductor:

12/04 EM10-F-CHM-069

Note: Representative Data Sheet. Refer to Forms Master list for current version.

Calibration Statement: Categories IV and V Equipment

Calibration is required before use per MPR-8730.5.

(Calibration before use for each test series and periodic testing by the Using LIne Organization)

Calibration Contacts: EM10/James Perkins, EM10/Mark Griffin

User Name:_____

Equipment Description:_____

(attach multiple components sheets if necessary)

Manufacturer:_____

ECN:_____ Serial No.:_____ Model No.:_____

Date of Calibration:_____

Type of Software and Version:_____

_____

Listing of Standards Associated with Calibration:

_____

_____

_____

_____

_____

Are standards National Institute of Standards and Technology (NIST) traceable? ☐ Y ☐ N

Did calibration meet equipment manufacturer's specifications? ☐ Y ☐ N

Calibration was performed by:_____

Remarks:

_____

_____

_____

_____

_____

_____

_____

_____

1/05 EM10-F-CHM-018

Note: Representative form. Refer to Forms Master list for current version.

Figure 7-3. Typical Calibration Statement.

8.0 Records

Records for Building 4623 shall consist of (a) memoranda that contain test results and that are stored electronically in the Materials and Processes Technical Information System (MAPTIS) and (b) calibration records.

8.1 Memoranda

Memoranda containing test results shall be retained indefinitely by EM10. These memoranda shall be stored electronically in the MAPTIS database and shall be accessible by test request number or memorandum number.

8.2 Calibration Records

8.2.1. All equipment requiring calibration shall be in current calibration, in accordance with EM10-OWI-CHM-050, *Building 4623 Guidelines for General Operations.*

8.2.2. Form EM10-F-CHM-018 (Figure 7-2, section 7.0) shall be used to document the calibration of all Category IV and Category V equipment.

8.3 Maintenance of Records

8.3.1. Memoranda less than 10 years old shall be maintained in ready-access files in MAPTIS; memoranda 10 years old or older shall be automatically transferred to historical files.

8.3.2. Calibration records shall be maintained on site for a minimum of 10 years, filed and indexed by test request number. These shall be stored in a manner that will protect them, *e.g.*, in a test folder stored in a metal file cabinet. After 10 years, calibration records shall be transferred to historical files.

8.3.3. The original test records shall be saved for a minimum of 5 years.

9.0 Tools, Equipment, and Materials

9.1 Equipment and Support Services

A small test sample is supported vertically in a mixture of oxygen and nitrogen flowing upward through a transparent chimney. The upper end of the test sample is ignited, and the subsequent burning behavior of the sample is observed to compare the period for which burning continues, or the length of the sample burned, with specified limits for each burning. By testing a series of samples in different oxygen concentrations, the minimum oxygen concentration is determined

The following equipment and services are used in support of the Oxygen Index Tester:

- A hood system with flow rate of 50 liters (*l*)/sec that allows the chimney to be positioned over the test sample once the holder is in position.

- Electrical power providing either 230VAC at 50 to 60 Hz or 110 VAC at50-60 Hz at the instrument shall be available via one wall socket. The Control Unit is equipped with a voltage selection switch.

- **A n**itrogen (oxygen free) and oxygen supply, capable of producing a flow of 14 *l*/min at a maximum pressure of 3 bar (43.5 psi). The nitrogen and oxygen shall both be metered via a multi-stage pressure regulator capable of displaying the supply pressure and the outlet pressure.

  Note: A single-stage regulator is unable to maintain the pressure to the control unit. Bottled propane with a regulated supply pressure of under 1 to 2 bar (14.5 to 29.0 psi) shall be connected to the supplied igniter.

  Note: The manufacturer recommends that gas pressures of 2 bar be used for the standard flowmeter (1-12 *l*/air) and that gas pressures of 2.75 bar be used for the 2-25 *l*/min air scale (for compatibility with a 100-mm diameter chimney.)

The tester shall be located in a draft-free environment at a temperature of 23 (±2) °C [73.4 (±3.6) °F].

9.2 Standard Configuration of Oxygen Index Tester

The Oxygen Index tester (Figure 9-1) consists of a control unit, a separate glass chimney, two types of test sample holders, and a hand-held propane igniter. The entire assembly, including the chimney, stands 750 mm high, 365 mm wide, and 364 mm deep. (A bench depth of 630 mm is required for making gas and power connections.) The mass of the assembly is ~15 kg. The tester components are described below.

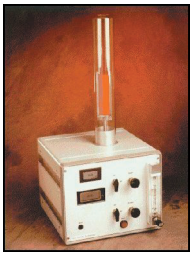


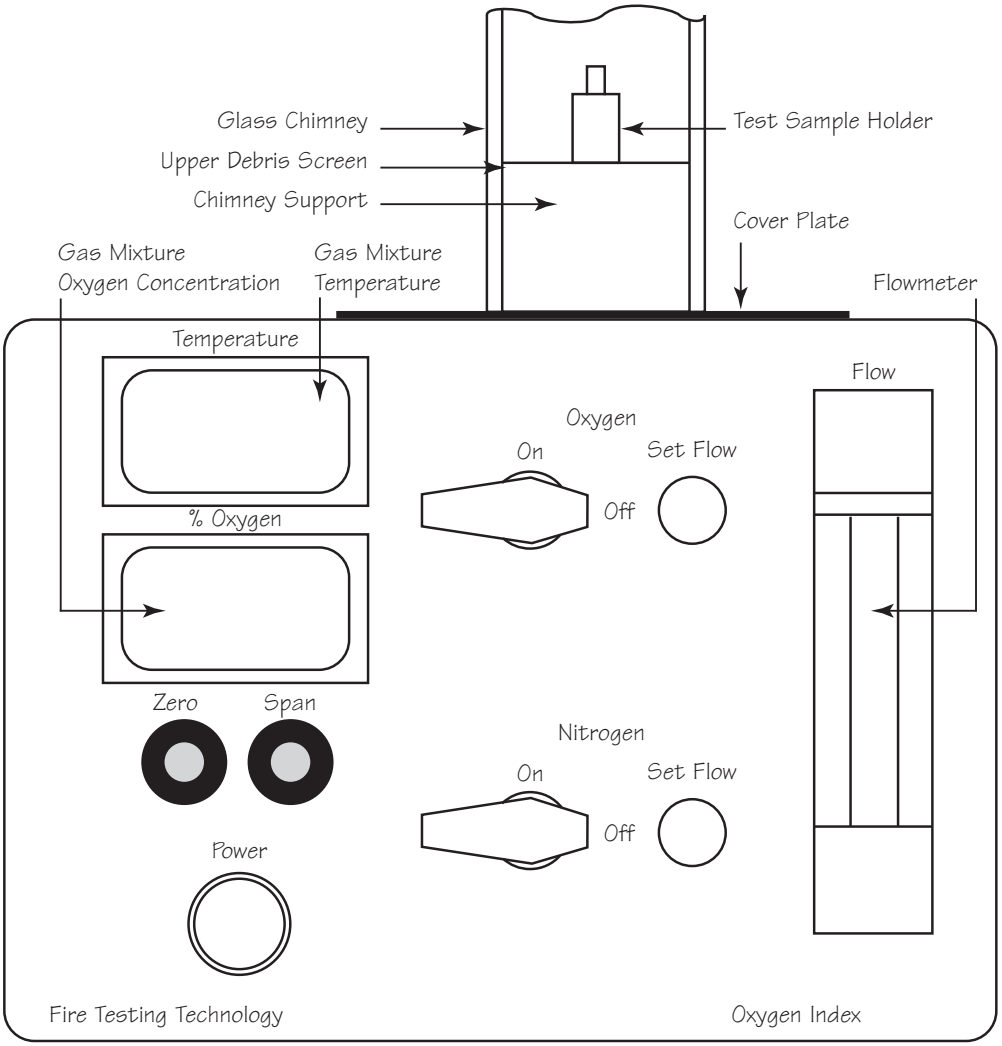
Figure 9-1.
Oxygen Index Tester

9.2.1. Control Unit

9.2.1.1. Front Panel (Figure 9-2): Located on the front panel of the unit are the following controls:

- Temperature indicator (for type K thermocouple)
- Oxygen concentration indicator (paramagnetic oxygen analyzer) and adjust for zero and span
- Power **ON/OFF** push button switch, which operates by firm pressure and lights up when activated
- **ON/OFF** ball valves for both nitrogen and oxygen
- Needle valves for both nitrogen and oxygen
- 1-12 *l*/min air flowmeter

Figure 9-2.
Control Unit (front)



Note: Illustration is representative. Actual appearance may vary.

9.2.1.2. Rear Panel (Figure 9-3): Located on the rear panel of the unit are the following items:

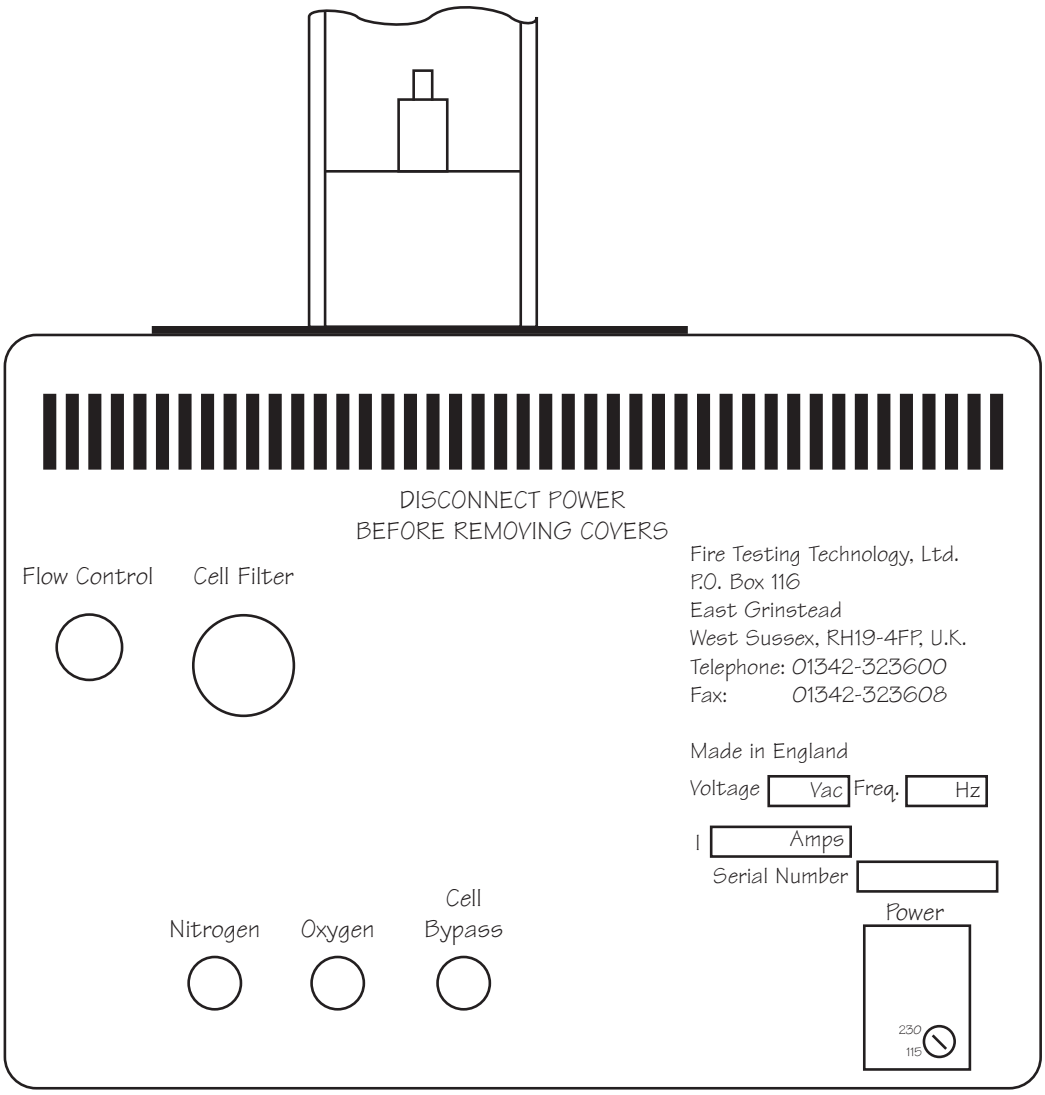


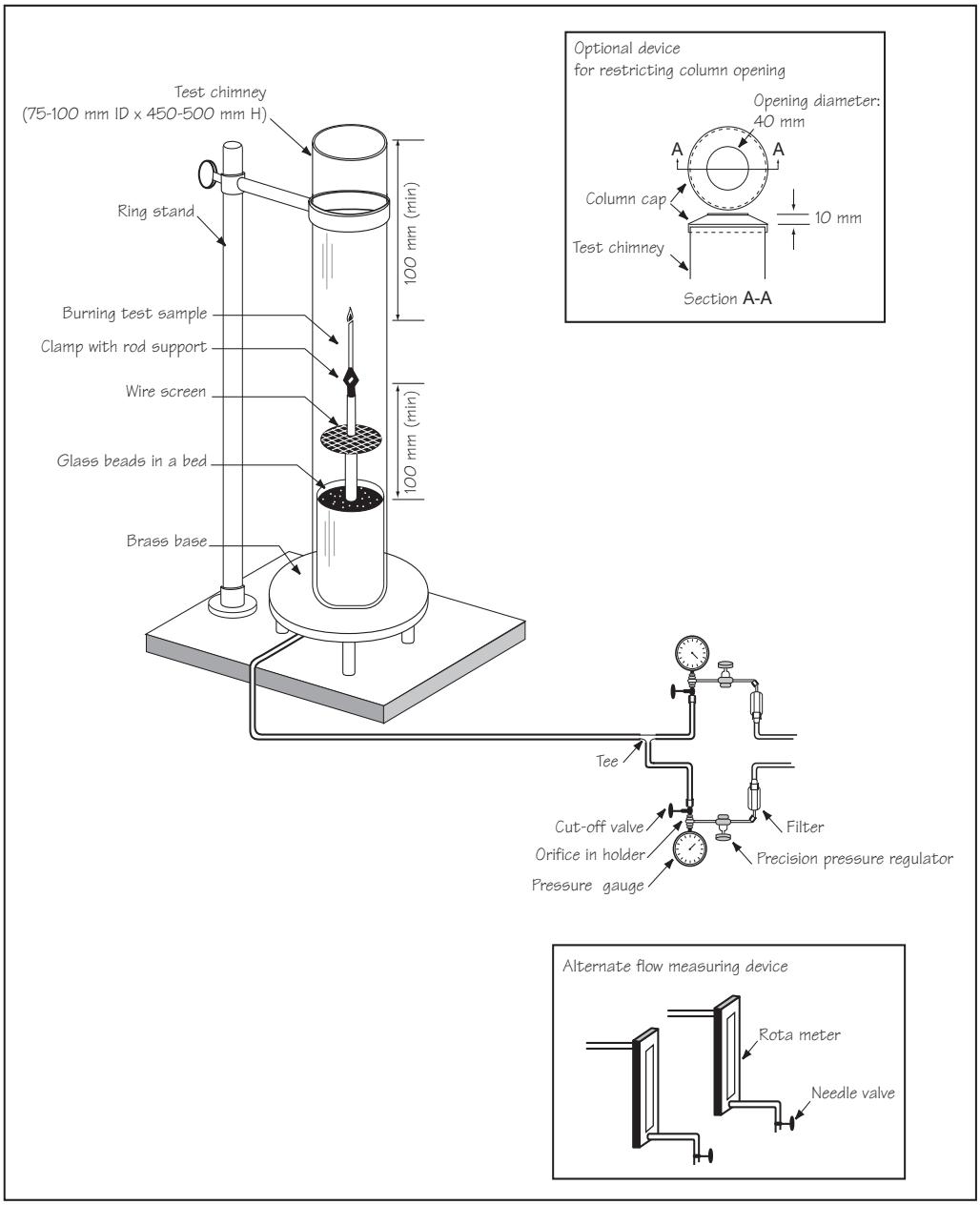
Figure 9-3.
Control Unit (rear)

Note: Illustration is representative. Actual appearance may vary.

- Flow Control needle valve (for Flostat MNBB21)
- Oxygen analyzer cell filter
- Nitrogen and oxygen inlet ports (requires connection pipes of 6-mm internal diameter)
- Cell and bypass outlet from the oxygen analyzer
- Fused 2-A, 3-pin main inlet for main power input with voltage selection switch. Voltage options are: 230 VAC/50-60 Hz and 110 VAC/50-60 Hz earth ground)

9.2.2. Test Chimney (Figure 9-4): The chimney, manufactured from 2.5-mm thick borosilicate glass, stands 462 (±7) mm tall. The 450-mm chimney has a constant internal diameter of 75 mm, with the remainder of the height being of a tapered design terminating in an ~41.5-mm opening.

Figure 9-4. Typical Equipment Layout.



Note: Illustration is representative. Actual appearance may vary.

9.2.3. Test Sample Holder: Two types of test sample holders are supplied: one for materials of Types I, II, III, IV, and VI and one for materials of Type V, which includes reference marks (Figure 9-5).

9.2.4. Flame Igniter: The igniter system consists of a propane gas cylinder connected by flexible tubing to a hand-held neck valve, which has a stainless steel tube [ID 2 (±1) mm] screwed into it. The tubing is shaped to allow a small flame to be inserted easily into the chimney from its top end while holding the handle (below the neck valve) in a vertical orientation. The assembly is capable of producing

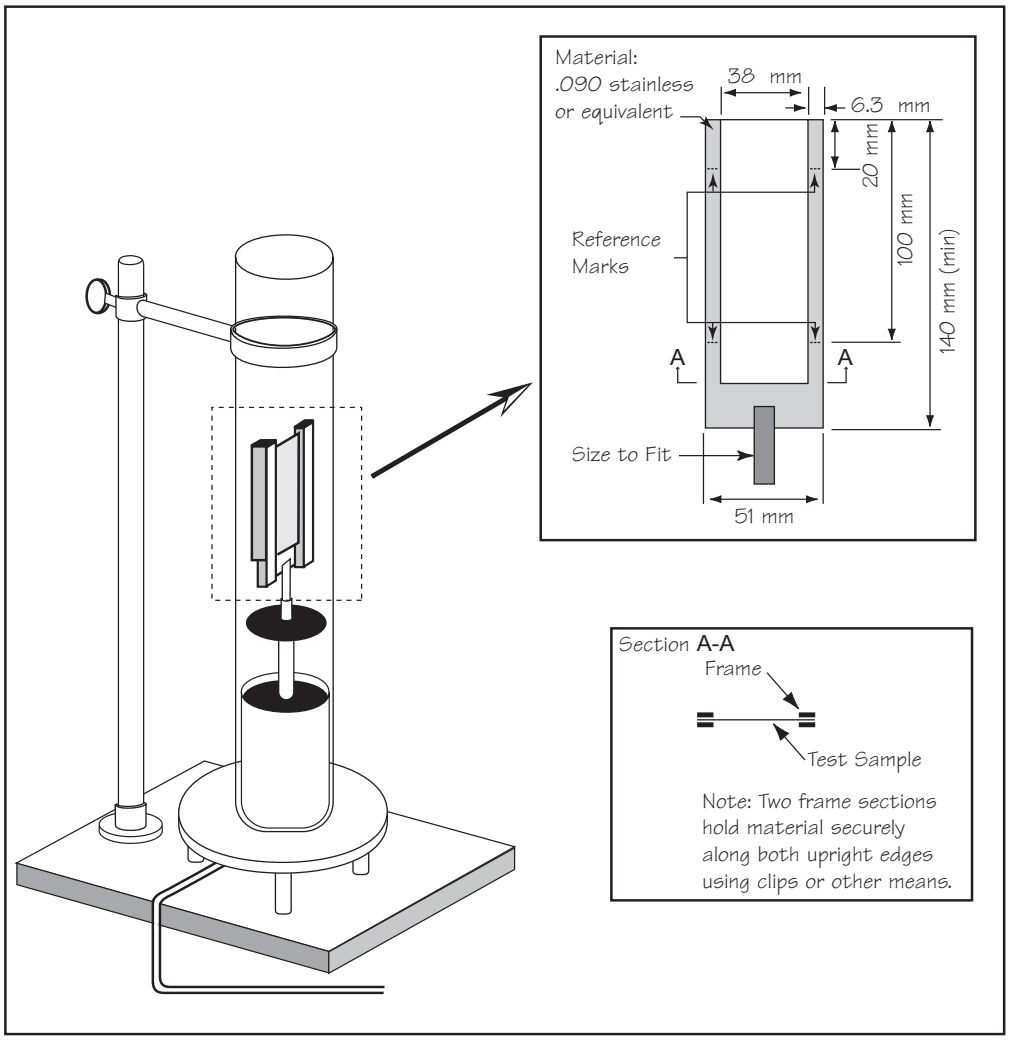


Figure 9-5.
Typical frame design for thin film and sheet test samples.

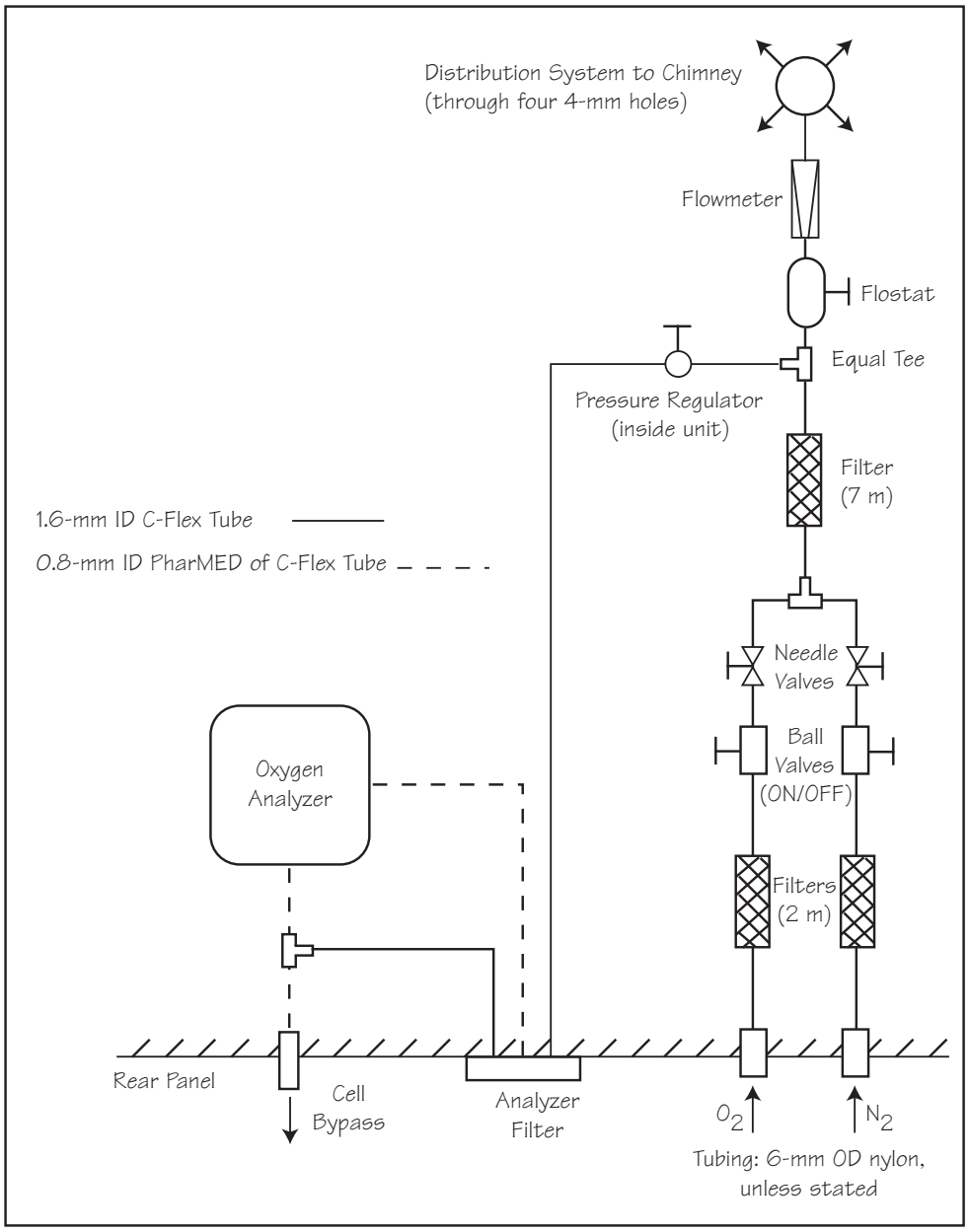
Note: Illustration is representative. Actual appearance may vary.

a flame that projects 16 (±4) mm vertically downward from the outlet when the stainless-steel tube is vertical within the chimney and the flame is burning in the chimney atmosphere.

9.2.5. Gas Circuit (Figure 9-6): Both nitrogen and oxygen are filtered before passing first through an ON/OFF ball valve and then through a needle valve. The gases are then combined at an equal tee, and full mixing is verified by the presence of a 7-µm filter. The majority of the gas mixture passes through the Flostat, the flowmeter, and the chimney to atmosphere. A small proportion is taken by the oxygen analyzer and then vented to atmosphere through the Cell and Bypass Port on the rear of the unit. The pressure regulator before the oxygen analyzer verifies that the maximum operating pressure of the analyzer (10 psi) is not exceeded. Any excess pressure is automatically vented to atmosphere at the regulator.

CAUTION: Under no circumstances shall the setting of the pressure regulator be altered.

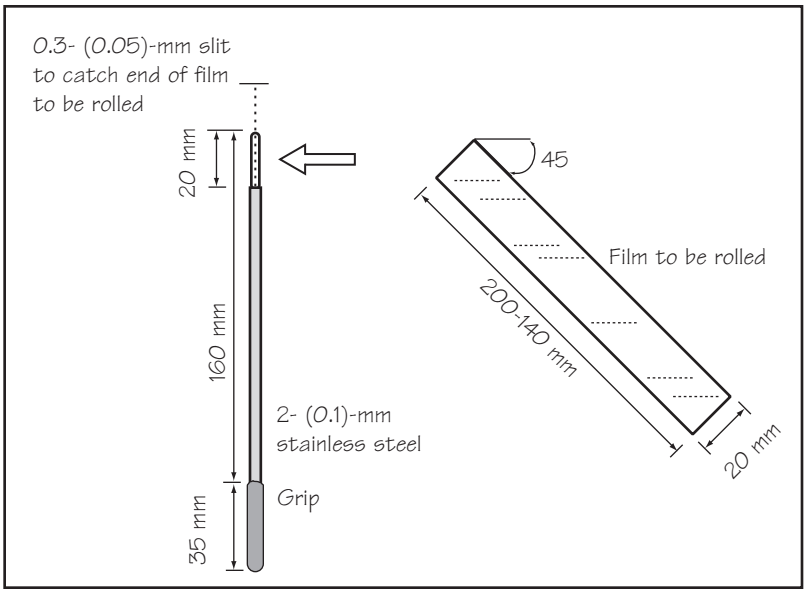
Figure 9-6. Gas Circuit.



Note: Illustration is representative. Actual appearance may vary.

9.1.6. Thin Film Rolling Tool: a 2- (±0.1-) mm stainless steel wire with a 0.3- (±0.05) mm slit at one end (Figure 9-7).

The hardware standard configuration is controlled by the *Oxygen Index Tester Configuration Control Book*, which is controlled by NASA.



Note: Illustration is representative. Actual appearance may vary.

Figure 9-7.
Typical thin film rolling tool.

9.3 Procedure for Deviations

Deviations to the baselined tester configuration require NASA written approval. The test engineer shall obtain the written approval. After written approval is received, the change shall be added to the *Oxygen Index Tester Configuration Control Book*.

9.4 Tester Maintenance

The standard maintenance program for the oxygen index tester and related control equipment is performed on a post-test basis. In addition, the program involves a maintenance log, calibration, and a required spare parts inventory.

9.4.1. Post-Test Maintenance: **Clean** glass chimneys using non-abrasive cleaners. **Remove** and **clean** debris screens, ensuring that no material remains trapped in the holes.

9.4.2. Maintenance Log. The test operator **shall document** any maintenance to the OI tester or setup in the *Oxygen Index Tester Maintenance Log* to provide a history of the tester. Any deviation to standard maintenance shall be documented by the test operator and approved on the maintenance log by the responsible test engineer.

9.5 Calibration

The Calibration Laboratory **shall calibrate** the flow measuring system using a water-sealed rotating drum meter (wet test meter) in accordance with ASTM Test Method D 1071 or by equivalent calibration devices. The maximum interval between recalibration shall be 6 months. A Type I test sample of cast PMMA **shall be used** as a calibrator at least once a month. The PMMA shall be a non-modified transparent cast sheet based on a homopolymer of methylmethacrylate in accordance with Specification ASTM D 4802, Category A-1 (ISO7823-1 for Cast Sheets).

9.6 Required Spare Parts Inventory

The test operator **shall verify** that the spare parts listed in Table 9-1 are available at the beginning of each test request, so that the testing of a material is completed as close to within 1 working day as possible.

Table 9-1. Required Spare Parts Inventory for Oxygen Impact Test.

Part	Quantity	Drawing #/Description
Please complete table		

10.0 Personnel Training and Certification

The nature of testing that occurs in the Building 4623 is complex and involves potential hazards; therefore, all oxygen index test operators **shall be** Category 1 certified before conducting any test, and all OI tester maintenance personnel **shall be** Category 2 certified. This section describes the two levels of certification:

- **Category 1 Certification** qualifies personnel to perform basic test operations.
- **Category 2 Certification** qualifies personnel to maintain and modify testing apparatus.

Category 1 - Basic Operations

To be certified, all OI test operators must complete training in the following areas:

- Handling of Compressed Gas Cylinders
- Oxygen Compatibility
- Use of Personal Protective Equipment
- General Safe Laboratory Practices
- Hazardous Waste Disposal.

Category 1 Certification also requires an annual physical examination conducted by the medical facility at Marshall Space Flight Center (or equivalent), including a hearing exam.

The operator **shall demonstrate** knowledge of the test and equipment by completing two successful test sets under the supervision of the test engineer. There is no emergency shutdown procedure for this tester.

Test operators **shall thoroughly read** the test OWI as part of the certification process. They **shall sign** a statement that they have read and understand the OWI and **shall be issued** personal copies of the OWI. The test engineer **shall give** the candidate a written test covering the OWI. A copy of this test, along with the signed statement and the training record, **shall constitute** verification of certification. Training records **shall be kept** on file as proof of training. These records **shall include** training expiration dates and required refresher courses.

These certifications **shall expire** after a period of 2 years. After that time, recertification **shall be** required.

Category 2 - Tester Maintenance and Modifications

Personnel seeking **Category 2 Certification** shall become qualified and certified in the following areas:

- *Compressed Gases and Working with Compressed Gas Lines and Fittings*
- *Basic Electrical Wiring.*

This qualification/certification **shall be achieved** through training classes approved by the candidate's supervisor or through training classes completed during previous employment.

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EMERGENCY PHONE NUMBERS

Emergency..... 911

Medical Center..... 4-2390

Industrial Safety..... 4-0046

Chemical Spills..... 4-4357

Safety Monitor
Building 4623..... 4-3571